Egyptians conceived as inhabiting the tomb-world; and occasionally sarcophagi were ornamented in the same manner. Some of the best illustrations in Dr. Budge's book are taken from the sculptures of Seti's sarcophagus.
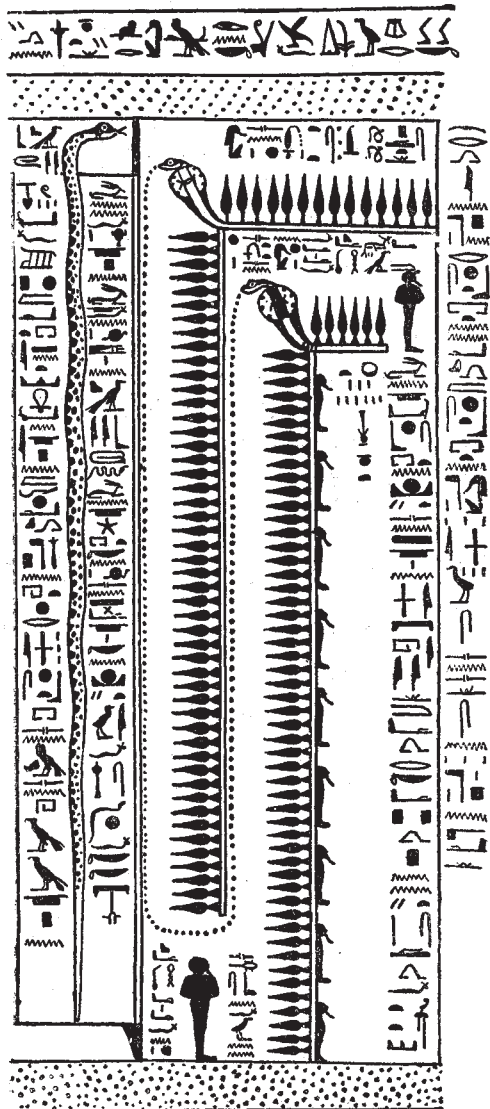
The conceptions of the rewards and punishments



FIG. 2.—The Gate of the Serpent Agebi. From "The Egyptian Heaven and Hell," vol. ii., The Book of Gates.

of the dead in the next world as given in these two books are also well worth the attention of the anthropologist.

## ANCIENT ECLIPSES.

THE results of recent discussion of ancient eclipses may for convenience be divided into three sections. The conclusion of each section depends upon the truth of the conclusions of the preceding sections, but not vice versâ, that is to say, the results of the last section may be rejected without in the least impairing the validity of the earlier conclusions. The results are as follows :—

(1) If an astronomer had been asked a year ago by a historian or a chronologist whether the tables of the sun and moon accurately accounted for the recorded phenomena of ancient eclipses, he could only have replied that the tables failed altogether to account for the solar eclipses; that they had been empirically altered so as to account for the observed *times* of certain lunar eclipses; and that the question whether the tables so altered accounted for the *magnitudes* of the same lunar eclipses had not even been examined. There seemed to be no possible modification of the tables that would bring them into harmony with the recorded solar eclipses, and it was therefore the received opinion that the historical accounts of these were untrustworthy. The first result is that two slight modifications of the existing tables will cause them to satisfy the records.

The modifications in question may be stated as follows :—Define the nodical month as the mean period between one passage of the moon from south to north of the ecliptic and the next passage, and define the nodical year as the mean period between one passage of the sun from south to north of the plane of the moon's orbit and the next passage, purely periodic variations being left out of account. Then the eclipses show that the rate of change of length of both the nodical month and nodical year as given in the tables must be altered.

(2) The second section of the results is concerned with the question, " In order to alter the rate of variation of the nodical year, are we to alter the acceleration of the node or of the sun? " Now the motion of the node depends upon theory, and the same theory which accounts for its motion at the present time will suffice to calculate its motion at any time during the last few centuries. The motion of the sun, however, is purely a question of observation. Unknown causes may easily be conceived as altering its motion. The second result is therefore to ascribe an acceleration to the sun's motion to account for the variation in the nodical year inferred from ancient eclipses, or in other words, we may leave out the word " nodical " in our statement and say, " The ancient eclipses indicate certain definite rates of change in the lengths of the month and year."

(3) We lastly require some physical explanation of the sun's acceleration. Here there are many possibilities. The æther may offer a sensible resistance to the passage of the earth; or an electro-magnetic theory of gravitation may compel us to take account of the small, but not infinitesimal, ratio between the velocity of a planet in its orbit and the velocity of light; or again, electrical theories of matter somewhat modify the old conception of mass, and with it the fundamental equations of motion on which planetary theory rests. But the explanation tentatively put forward at the April meeting of the Royal Astronomical Society is as follows :—Let us suppose the acceleration of the sun to be due to a change in the length of the day caused by tidal friction. The tides check the rotation of the earth, lengthen the day, and therefore apparently increase all diurnal movements by the same fraction of their whole amounts. Introducing numbers for greater definiteness, let us suppose that in a century the day increases in length by a two-hundredth part of a second of time. Then in a century the sun's apparent rate of motion will increase by one part in seventeen million, which is exactly the change indicated by the eclipses. If, however, the moon's apparent rate of motion also increased by one part in seventeen million the acceleration would be ten times larger than that indicated by the eclipses.

But if the tides are checking the diurnal rotation of the earth, it follows from the principle of conserva-

tion of angular momentum that the moon must be receding from the earth, and absorbing the spin lost by the earth. This implies that the moon is really moving more slowly. It is impossible to make accurate calculations, for the action of the tides on an earth with oceans and continents of irregular shape cannot be computed, and it is impossible to say how the tidal action varies for different positions of the moon in its elliptic orbit. Hence we cannot say how far the action of the tides is distributed between changes in the length of the month and changes in the eccentricity of the moon's orbit. But it seems a plausible hypothesis that the large eccentricity of the moon's orbit was evolved somehow, presumably by tides, and that the eccentricity is therefore increasing, and calculation shows that if the rate of increase assigned to the eccentricity be about one-hundredth of a second of arc a century, the consequent change in the absolute angular velocity of the moon is such as to cancel nine-tenths of the apparent decrease in the length of the month, leaving the remaining one-tenth in agreement with the change inferred from ancient eclipses. This explanation, it should be clearly understood, only shows that certain correlated quantities are of the right order of magnitude : it is unable to prove or disprove an exact numerical relation.

In the remaining part of this article the basis of the conclusion of the first section is examined. That is the foundation, which must be rendered secure before interest can attach to any superstructure.

Let us select a definite eclipse, for instance, the eclipse of Thucydides in the first year of the Peloponnesian War. The record states that stars appeared. It is certain on the other hand that the eclipse, at the most, could only have been annular. There is therefore a strong presumption that Athens was not far from the central line of the eclipse, or in other words, at the time of conjunction in longitude as seen from Athens, the difference of apparent latitudes must have been small. The hypothesis that Athens was the place of observation has been objected to. This however is the natural interpretation of the passage in Thucydides ; let us adopt it for the present and see where it leads. For Athens, therefore, let the difference of apparent latitude for the instant of apparent conjunction in longitude be computed from the present tables. The result is so large as absolutely to negative the possibility that stars could have been seen. Reserving the hypothesis that the record is untrustworthy as a last refuge in case of trouble, let us suppose for the present that the tables require alteration.

What kind of alteration is permissible? It has been argued in *Ast. Nach.*, No. 3682, on physical grounds, that only one unknown quantity may be introduced. Now against physical reasoning of this kind, strong objections may be urged. It proceeds necessarily on the assumption that the general nature of the problem of the apparent motions of the sun and moon is fully understood. It absolutely limits the investigation to the numerical determination of quantities connected with a preconceived theory, and it prevents, at the outset, the attainment of results of a new character. Now as the preconceived theory was entirely based upon two centuries of observation, there is no improbability in our knowledge being widened, when the period of observation is largely increased. In the whole of astronomy there is not a single case of a theoretical value of a secular term, that is to say, a term proportional to the square of the time, being confirmed by observation. This is because the series of modern observations is not yet long enough. Is it not possible that one or two centuries hence the

observed values of these terms will lay bare a whole series of new phenomena? Physical considerations of the kind alluded to absolutely prevent the achievement of such a result. They may advantageously be replaced in the following manner by considerations of a purely geometrical character.

It being, for a time at least, granted that the eclipse of Thucydides suggests that the existing tables require large modifications, geometrical considerations tell us, that in order to diminish by $200''$ or thereabouts the difference of latitude at conjunction, we must alter the mean distances of the sun and moon from the node as given by the tables for the year $-430$ by quantities of the order of $2000''$. The only geometrical alternative is to assume alterations ten times as large in some other quantity such as the position of the perigee, and this alternative may be put aside. Now the mean distances can be expanded in powers of the time, the origin of time being taken near the present day. Then modern observations forbid the correction of the mean motions or of the terms independent of the time. The corrections are therefore necessarily thrown about the coefficients of the square of the time, that is to say, upon what are called the secular terms, in the mean distances of the sun and moon from the node. Geometrical considerations therefore, combined with a becoming modesty as to our powers of applying physical considerations, present us with two unknown quantities for correction, one of which is the quantity admitted in *Ast. Nach.*, No. 3682 to be arbitrary, while the other is a new one.

If the preconceived theory is correct and the records are trustworthy the value of the second variable will or solution turn out to be zero or so nearly zero as to suggest that zero is the true value. If no values satisfy all the equations of condition, then some of the records are untrustworthy or the geometrical considerations have been carelessly thought out. If the equations can be satisfied simultaneously, and the value of the second variable is not zero, a very strong case is established against the physical considerations of the preconceived theory.

If we write down five simultaneous linear equations in two unknown quantities $x$ and $y$, all satisfied by the same values of the variables, and if we then put $y$ equal to zero, or in other words, rub out the terms in $y$, we shall of course find the equations in $x$ are inconsistent. If the equations represent historical data, and if, as men of science, we have a proper contempt for literature, we shall no doubt proceed to quarrel with our evidence. This is exactly the way in which astronomers have in the past treated ancient solar eclipses. When, however, equations of condition involving two unknown quantities are formed for all the solar eclipses in which the place of observation appears to have been fairly near the central line, whereas modern tables give residuals of the order of $200''$, that is to say, make the apparent differences of latitude at conjunction in longitude of the order of $200''$, values•can be found for the unknown quantities, which will make all the residuals less than $50''$ ; in other words, whereas the present tables would leave about ten per cent. of the sun's diameter visible, the alterations proposed never leave so much as two per cent. visible.

Let it be here stated that no solar eclipse is an exception to the above statement. The conclusions rest, not upon the evidence of a majority but upon the unanimous evidence of all eclipses used. A list of these is given in Monthly Notices, lxv., p. 861, and a reference is given on p. 867 to the eclipse of Agathocles. The eclipse of Thales has not been

worked up as it occurred a hundred years before the birth of Herodotus; its evidence, whether for or against, is held to be inadmissible.

A confirmation of these results is supplied by the lunar eclipses of the Almagest. On working them up, it is found that the residuals are so large as to show that they are entitled to far less weight than the solar eclipses. Their value lies in the fact that the separate determinations from the lunar eclipses group themselves round the values derived from solar eclipses. The lunar eclipses are given in Monthly Notices, lxvi., pp. 6–7; they are nineteen in number, and in only ten cases is a numerical estimate of the magnitude recorded. These ten cases alone therefore test the newly-discovered fact which, in language that becomes appropriate only if the second section of results is admitted, states that the earth's orbital motion is subject to a secular acceleration of $4''$. Now of the ten lunar eclipses available, seven give accelerations lying between $2''$ and $6''$. It is therefore hard to believe that zero and not $4''$ is the correct value. The times of the lunar eclipses are equally striking in their confirmation of the result. Nearly thirty years ago a correction was introduced into Hansen's Tables based upon these eclipses. The main question is one of evidence. It is no use to point out in the third section of this paper how certain changes may be accounted for, if they are not shown to exist. On the other hand, no objections to a particular explanation of the physical reason can weaken the case for the observed fact that these changes are taking place. What is sufficient evidence? Two eclipses would suffice, if they had been described with a wealth of detail that established complete confidence in the records. A hundred eclipses of the actual sort would probably satisfy the most sceptical, even though the place assigned were always "tacitly assumed (to be) the capital where the record was made, or the place where the poet or historian lived." The smaller number of eclipses, which it has alone been possible to produce, should suffice to make a case almost if not completely amounting to certainty.         P. H. COWELL.

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## VARIATIONS OF DOMESTIC POULTRY.[1]

THE book under notice is one of an original character. It is an attempt to describe all the different races of domestic poultry that exist in various parts of the world, and as such is not without its value, as it gives us a description of the races of fowls as they exist, not only in Asia, but in the various States of Europe and the United States of America. The book treats almost solely of the races of fowls from a fancier's point of view. The plumage and external characters which would be noticed in a show-pen are those that are dwelt upon, and as a scientific treatise the work cannot be regarded as having any special value, and would be unfairly treated if it were regarded from the same standpoint as Darwin's "Variation of Animals under Domestication."

The illustrations, which are very numerous, are not original, but taken from the fancy poultry journals, where the birds are drawn with the usual exaggeration of the points valued by the fancier, and bred for securing prizes. The consequence is that some of them are good and others quite the reverse, but the plumage in many is exaggerated. To scientific ornithologists this history of the location of colour in the different parts of the plumage of birds, and the

[1] "Races of Domestic Poultry." By Edward Brown. Pp. xi+234; illustrated. (London : Edward Arnold, 1906.) Price 6s. net.

fixture of the patterns in the races, is one of considerable interest. To those acquainted with the details of poultry breeding it is well known that any variation of the colour or texture of feathers which appears in any particular specimen can, by careful selection of the offspring, for a series of generations, be readily perpetuated, and by crossing with other varieties almost any pattern or disposition of colour can be obtained, and what is called a new breed formed. This is illustrated by the engraving, which we borrow from the work, of a German race at present but little known in this country, called the Lakenfelder. In this the colours are transposed from their general position, and a remarkable looking fowl is produced, which is correctly represented in the engraving.

It is of much scientific interest to trace the extent of the variation which can be induced by careful breeding. In the fowl, these variations have been almost exclusively confined to the plumage, which in some instances has been increased to an enormous extent, as in the production of quill feathers 8 inches long on the feet of the show Cochin, and the general
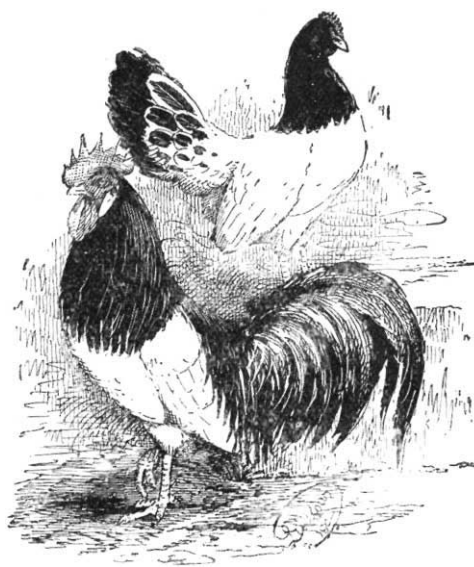


FIG. 1.—Lakenfelders. From " Races of Domestic Poultry."

increase of the plumage to a great extent, so that the modern show Cochin does not at all resemble the original birds brought from Shanghai. In other cases the plumage has been partially abolished, as in the Nackthälse or Transylvanian naked necks, in which the head and neck are entirely denuded of feathers, and the skin assumes the red colour of the comb. These variations are permanent, and are intensified by long-continued breeding. The production of spangles or dark markings at the end of the feathers, of bordered margins of black on a light ground in the whole of the body feathers, and of regular transverse bars across each feather of the plumage, have all been accomplished and perpetuated by careful selection.

The various breeds of ducks, geese, and turkeys are also treated of.

The work contains in an appendix a very elaborate and useful list of the names of the races in all the European languages, which will prove of great value to all investigating the subject of variation.

W. B. TEGETMEIER.